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Imaging
X-Ray
Polarimetry
Explorer

IXPE: Imaging X-Ray Polarimetry Explorer Mission

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Ball Aerospace

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- Overview of science
- Project partners and roles
- Technical summary
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- Conclusions

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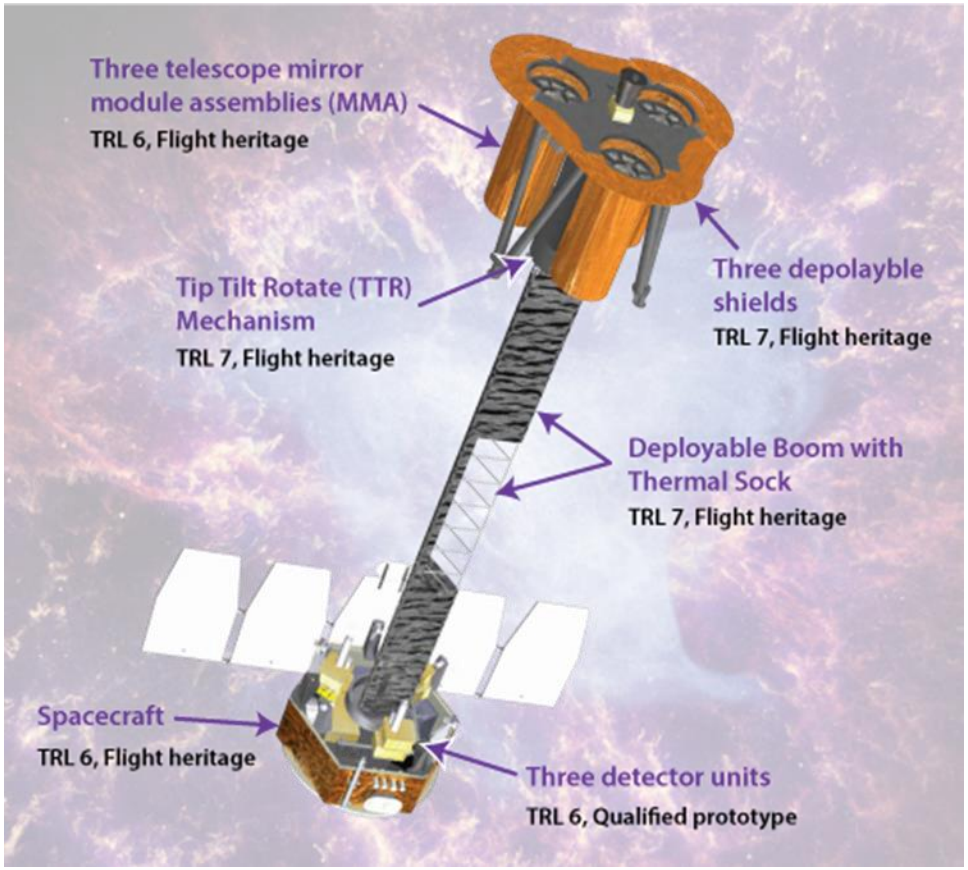
QUICK SUMMARY OF *IXPE*

- **NASA Explorer Mission, cost capped at $175M (FY15)**
- **PI:** Martin Weisskopf, MSFC
- **Class D Mission** managed by MSFC
- **LEO observatory** that measures spatial, spectral, timing, and polarization state of X-rays from 49 known astrophysical targets
- **Ball Roles:** Spacecraft, Payload mechanical, AI&T, and Mission Ops (with LASP)
- **MSFC**: Management, X-ray optics, SOC
- **ASI (Italian Space Agency):** Detectors Units, Ground station
- **Phase B** starts now; launch Nov 2020



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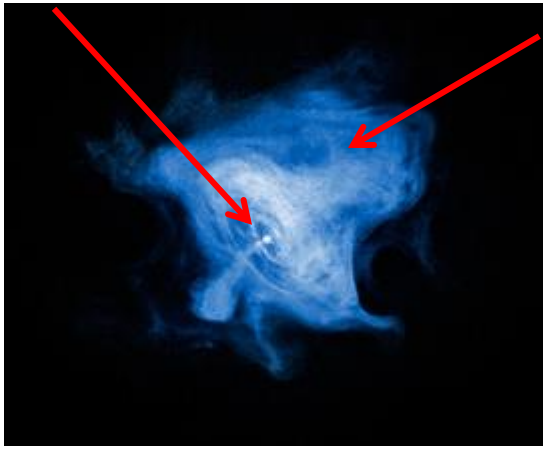
IXPE SCIENCE

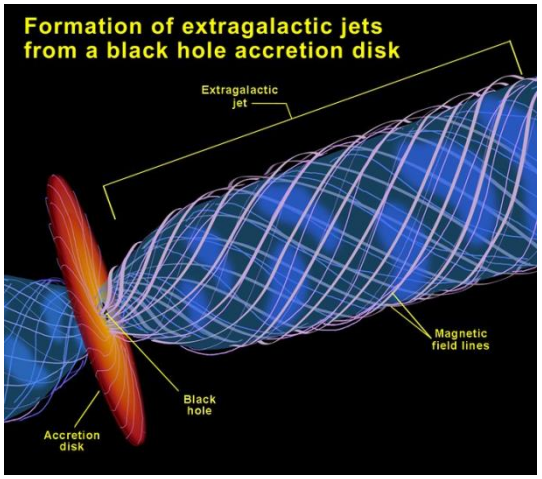
- **X-ray emission from energetic processes: In-fall of matter into Neutron Star or Black Hole, synchrotron or shock emission, or very hot regions**
- **Can originate both from point and extended sources; *Imaging* separates these sources**
- ***Polarization* of X-rays if there is anisotropy in emission geometry or mag field, plasma reflections, or general relativistic effects**

Crab Pulsar



Extended X-ray emission

Credit: NASA/SAO



Credit: NASA/ESA and STScI

Imaging separates regions with different emission mechanisms

Polarization probes the source geometry and mag field strength

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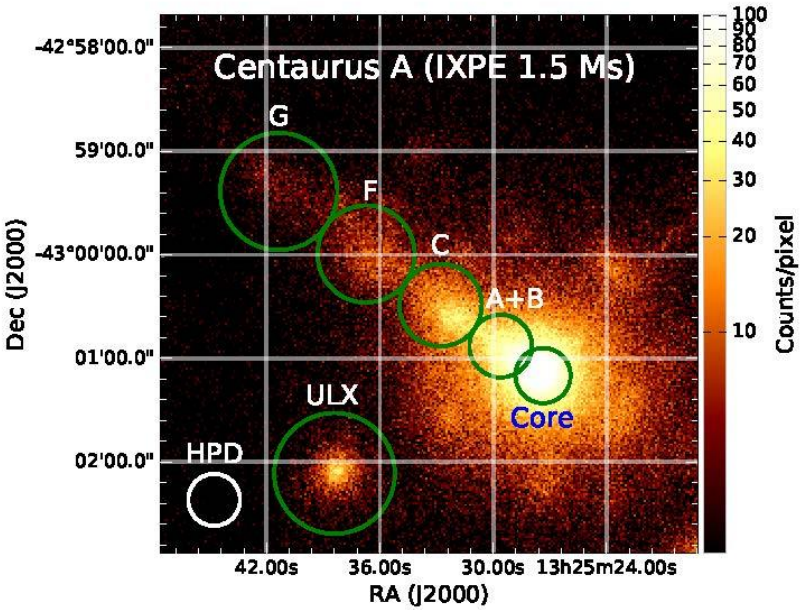
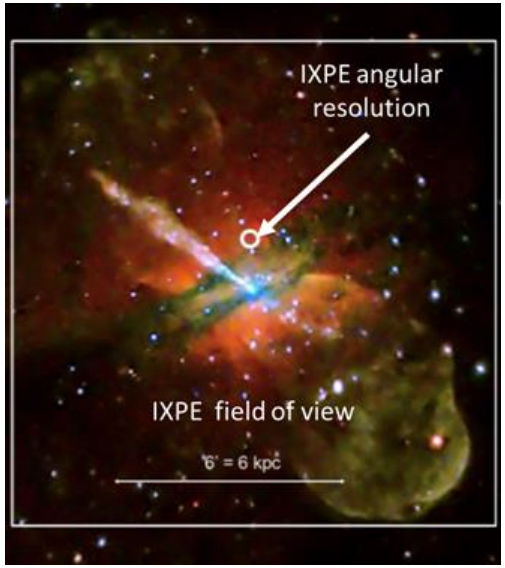
IXPE IMAGING LIMITS SOURCE CONFUSION

- **Active galaxies are powered by supermassive Black Holes with jets**
  - Radio polarization implies the magnetic field is aligned with jet
  - But other models also consistent with current observations
- ***IXPE* can image the Cen A jet and separate from other sources in the field (e.g., Ultra Luminous X-ray source)**





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IXPE Scientific Objectives

- **Science Objectives:**
  - Enhance our understanding of the physical processes that produce X-rays from and near compact objects such as neutron stars and black holes
  - Explore the physics of the effects of gravity, energy, and electric and magnetic fields at their extreme limits

- ***IXPE* addresses key questions in High Energy Astrophysics**
  - What is the spin of a black hole?
  - What are the geometry and magnetic-field strength in magnetars?
  - Was our Galactic Center an Active Galactic Nucleus in the recent past?
  - What is the magnetic field structure in synchrotron X-ray sources?
  - What are the geometries and origins of X-rays from pulsars?

Polarimetry of X-ray sources largely unmeasured
Opens a new window on the X-ray Universe

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Principal Team Members

- Principal Investigator
- Project Management
- Systems Engineering & SMA
- Mirror Module Design, Fabrication, & Calibration
- Science Operations Center (SOC)
- Science Data Analysis and Archiving

- Spacecraft
- SE and SMA Support
- Payload Structure
- S/C, Payload, Observatory I&T
- Mission Ops Management

- Mission Operations Center

- Detector System Funding
- Ground Station (Malindi)
- Mission Assurance (Italian contribution)

- Italian PI (IPI)
- Polarization-Sensitive Detector System
- Payload Computer

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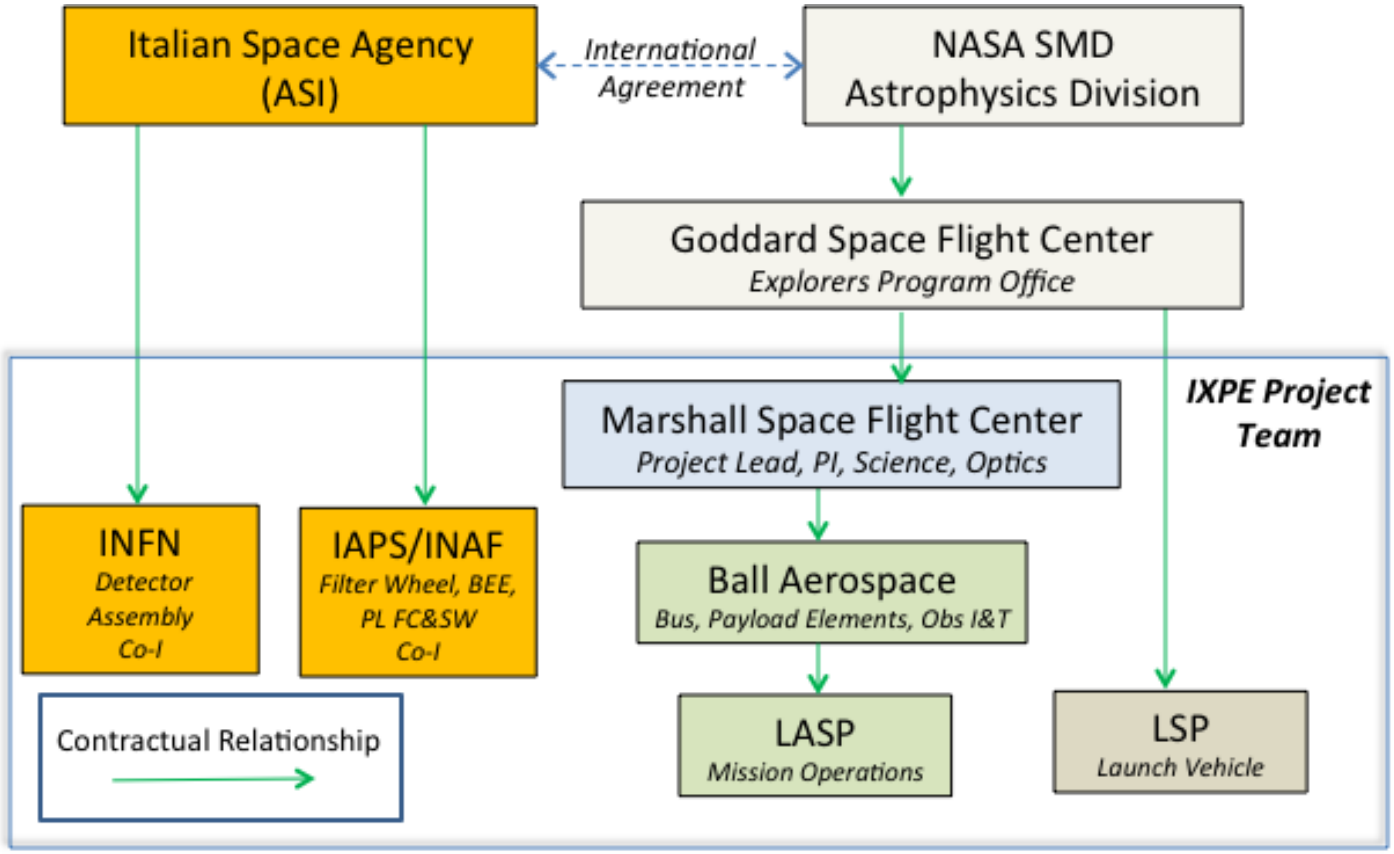
INTERNATIONAL RELATIONSHIPS



CLEAR INSTITUTIONAL ROLES, WITH WELL-DEFINED INTERFACES

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SCIENCE TEAM

- Martin Weisskopf, PI
- Brian Ramsey, Deputy PI
- Paolo Soffitta, Italian PI
- Ronaldo Bellazzini, Italian Co-PI
- Enrico Costa, Senior Co-I
- Steve O'Dell, Project Scientist
- Allyn Tennant, Co-I
- Fabio Muleri, Co-I
- Jeffrey Kolodziejczak, Co-I
- Roger Romani, Co-I
- Giorgio Matt, Co-I
- Vicky Kaspi, Co-I
- Ronald Elsner, Co-I
- Luca Baldini, Co-I
- Luca Latronico, Co-I

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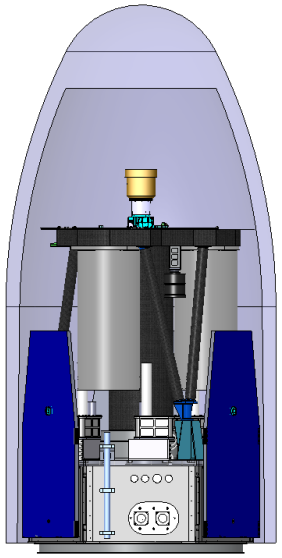
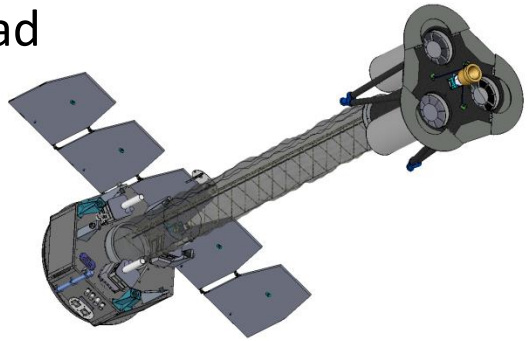
IXPE HAS A STRAIGHT FORWARD MISSION CONCEPT

- ***IXPE* Observatory is a single flight element**
- **Observatory launched to a 540 km, 0° orbit**
- **Pegasus XL launch vehicle is baselined**
- **3 critical events occur within ground or TDRSS contact**
  - Separation from launch vehicle (TDRSS) – free flying S/C
  - Solar array deployment (TDRSS) – full power available
  - Payload boom deployment (Malindi) – ready for payload commissioning
- **Observatory comm via S-band link**
  - Half of available Malindi contacts meet data download requirements for high data rate targets (e.g. The Crab)
    - Most targets require only 2 (of 15 available) contacts per day





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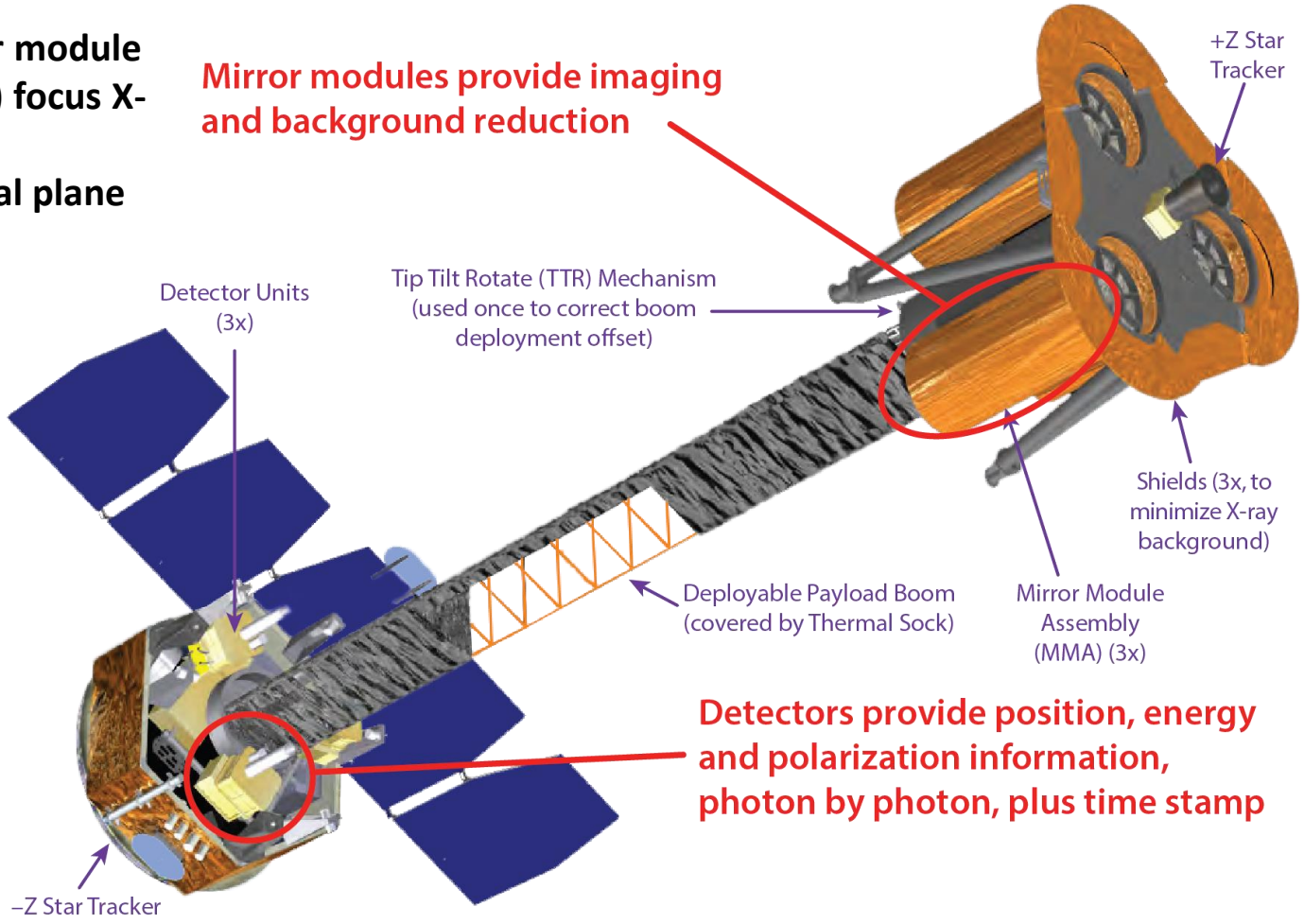
PAYLOAD OVERVIEW

Set of three mirror module assemblies (MMA) focus X-rays onto three corresponding focal plane detector units



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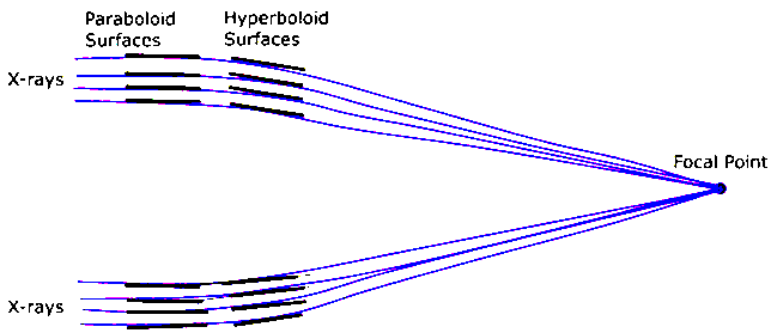
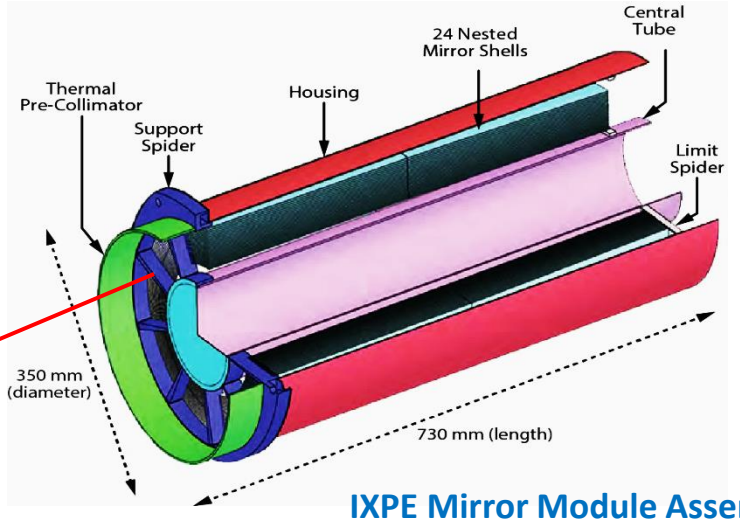
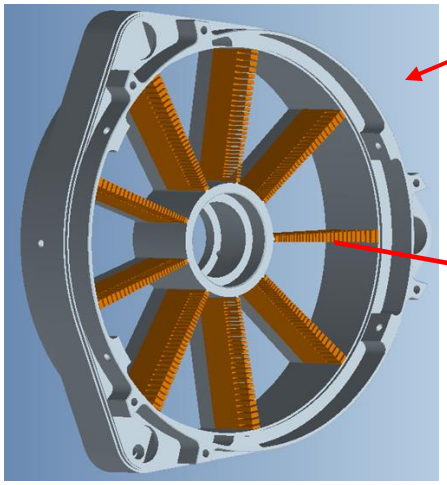
Mirror Module Design





IXPE Mirror Module Assembly



Rigid Support Spider

Shell Mounting Comb

Heritage Design Approach

- Electroformed Ni shells use a proven fab process
- Mounting combs provide shell attachment points
- A single rigid spider supports the 24 nested shells and attach module to structure

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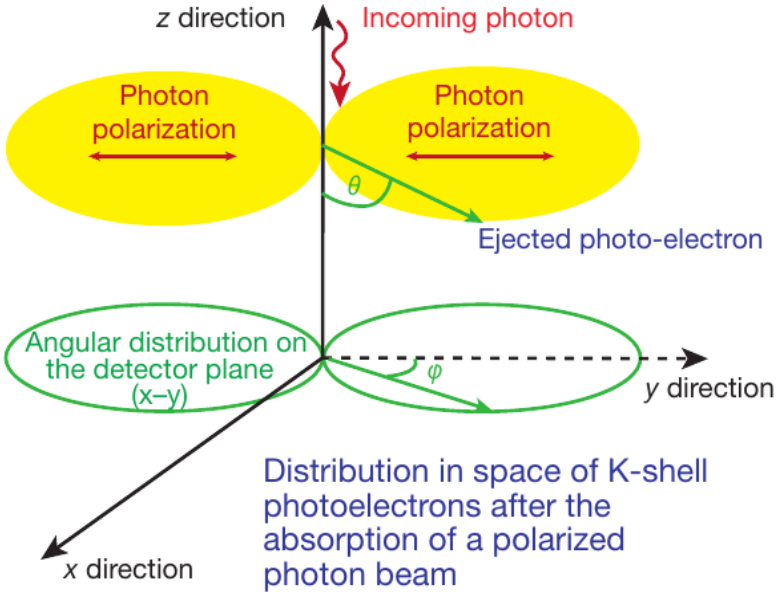
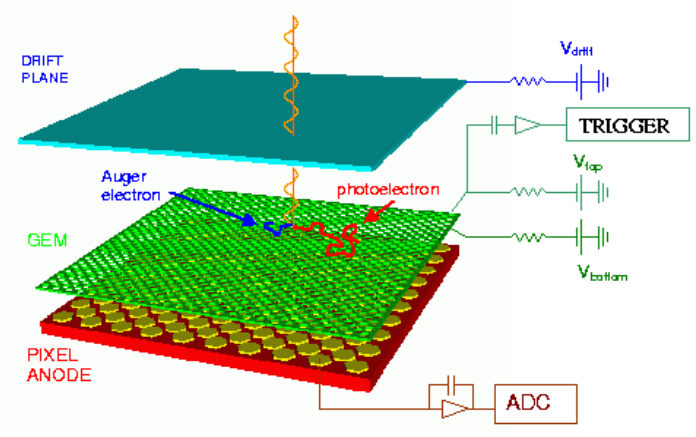
DETECTOR A CONTRIBUTION FROM ASI

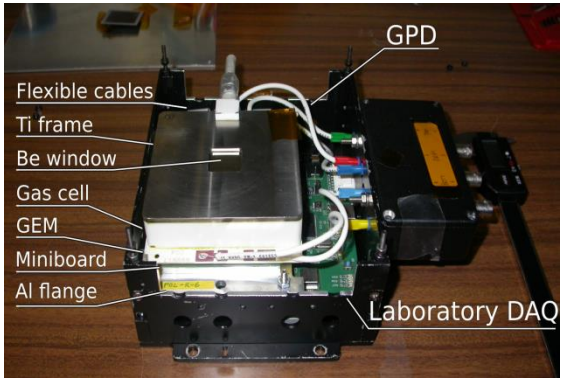
- **Detection uses photoelectric effect**
- **X-rays absorbed in detector fill gas**
- **Photoelectron emission aligned with X-ray polarization vector**
- **Electron multiplier with pixelated detector**



Gas Pixel Detector (GPD)



TRL 6 Prototype same form/function as FM



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End-to-End Flow from Detected Photon to Scientific Data Products

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IXPE HAS SUBSTANTIAL TIMELINE AND TECHNICAL MARGINS

- **Design Reference Mission (DRM) targets studied in detail during Year 1**
  - Year 2 is available for follow up observations, targets of opportunity, survey of additional sources
- ***IXPE* also has high technical margins**

Characteristic	Requirement	Capability	Margin
Launch Mass	291.7 kg	380.0 kg	30.3%
Science Data Storage	4 GB	6 GB	50%
EOL Science Mode Power Generation w/30° offset	188 W	257 W	37%
LOS Pointing Accuracy	53.1 arcsec (3σ)	25.2 arcsec (3σ)	110%
LOS Co-alignment Accuracy, X-axis	19.8 arcsec (3σ)	9.5 arcsec (3σ)	107%
LOS Co-alignment Accuracy, Y-axis	26.7 arcsec (3σ)	12.8 arcsec (3σ)	109%
LOS Pointing Knowledge	34.5 arcsec (3σ)	17.3 arcsec (3σ)	100%
Link Margins	>3 dB	>3.9 dB	>3 dB

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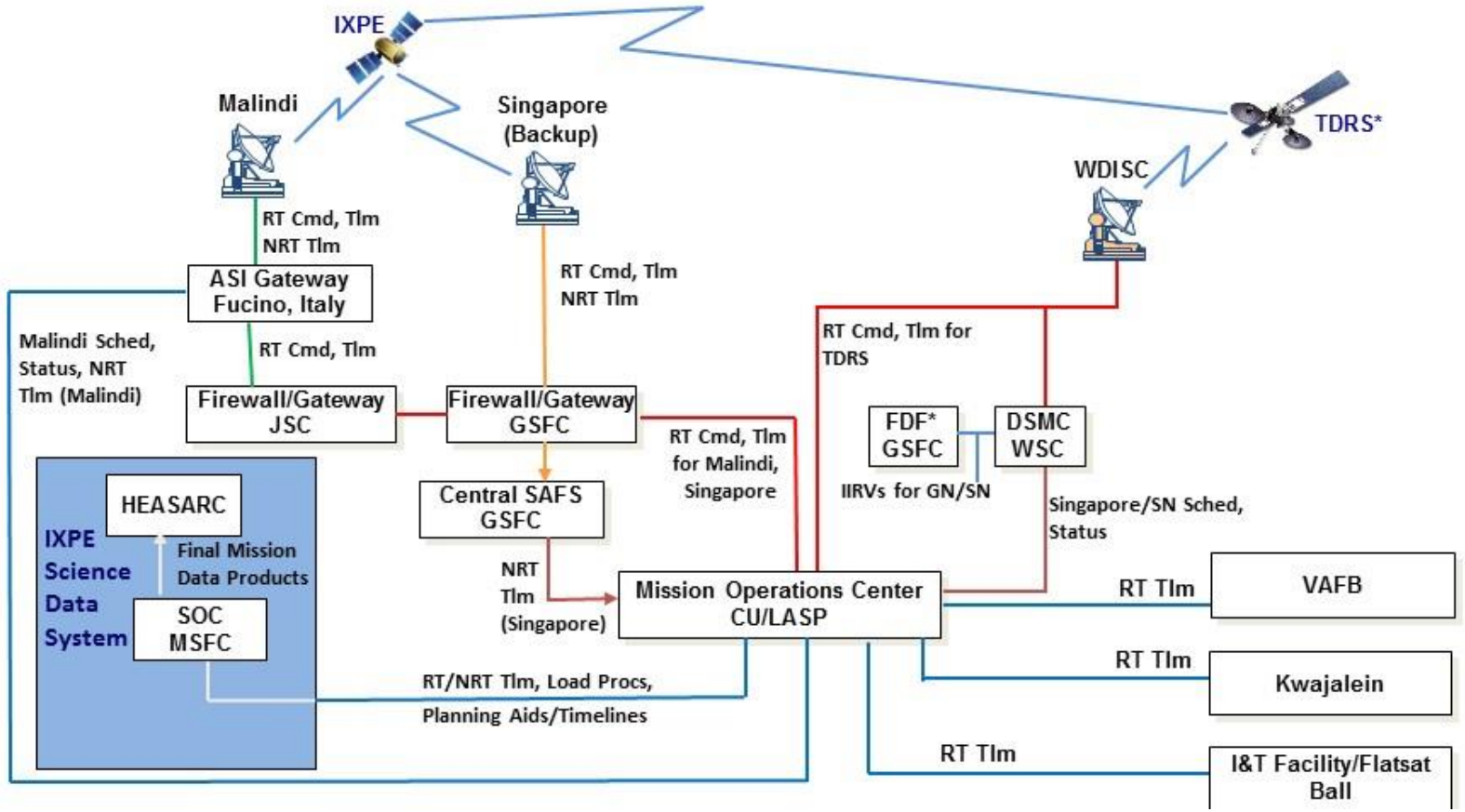
IXPE USES HERITAGE GROUND DATA SYSTEM



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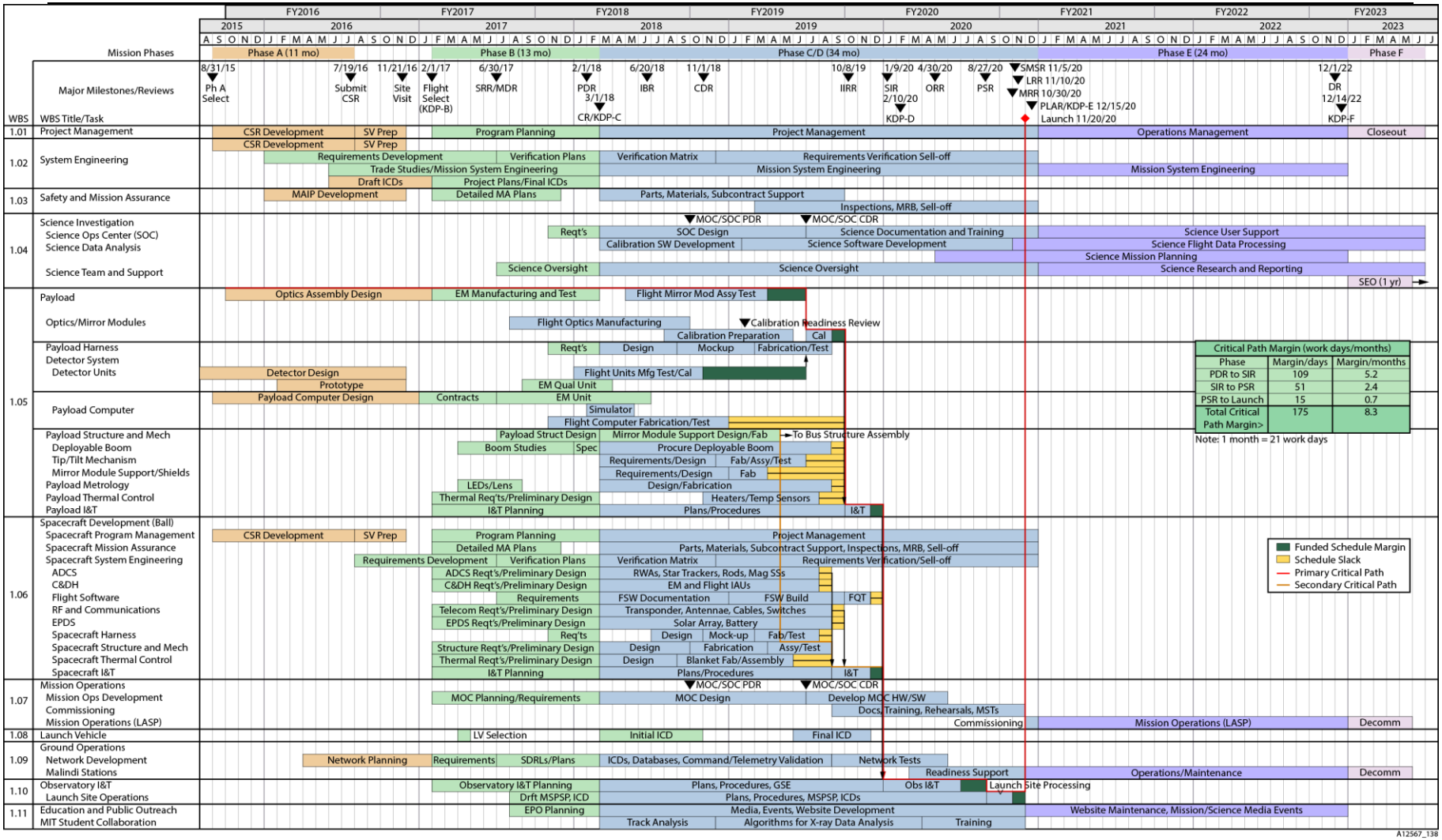
IXPE INTEGRATED MASTER SCHEDULE



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CONCLUSIONS

- IXPE Project Phase B Kicked off in February 2017
- SRR planned mid-September 2017
- PDR planned February 2018
- Observatory built up from heritage elements
- X-ray optics build starts at MSFC 2017
- Gas-pixel detector fabrication starts 2017
- Launch planned November 2020

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- The work described in this presentation is a culmination of efforts from teams at NASA MSFC, Ball Aerospace, ASI, INFN, IAPS, LASP, Stanford, McGill, Roma TRE